

CURRENT ICING POTENTIAL

Product Description Document

Part I - Mission Connection

- a. **Product Description** - The Current Icing Potential (CIP) product is an automatically-generated index of icing potential developed by the In-Flight Icing Product Development Team sponsored by the Federal Aviation Administration's Aviation Weather Research Program. The previous CIP 40 kilometer (km) horizontal resolution product was declared operational by the NWS in March 2002. The new CIP has been improved by applying new physical concepts, and by using improved dataset inputs. The CIP is now running on the RUC 20 km native Hybrid B Grids, generating output grids at both the 20 and 40 km horizontal resolution.
- b. **Purpose** – The CIP algorithm combines satellite, radar, surface, lightning and pilot report observations with model output to create a detailed, three-dimensional, hourly diagnosis of the potential for icing and supercooled large droplets (SLD) to exist. It uses a physically-based, situational approach that is derived from basic and applied cloud physics, combined with forecaster and on-board flight experience from field programs. Both fuzzy logic and decision tree logic are applied in this context. CIP determines the locations of clouds and precipitation, and then estimates the potential for the presence of supercooled liquid water and supercooled large droplets within a given airspace. CIP provides a real-time diagnoses that allow users to make route-specific decisions to avoid potentially hazardous icing.
- c. **Audience** - The CIP total icing potential product was approved for limited operational use by the Aviation Weather Technology Transfer (AWTT) board with member from the Federal Aviation Administration (FAA) and the NWS. The CIP is meant to be used as a supplement, not as a substitute for the icing data contained in AIRMETs and SIGMETs. It is authorized for use by operational meteorologists and trained dispatchers only.
- d. **Presentation Format** - Both the CIP 20 km and CIP 40 km GRIB output are available through:
 - 1. The AWIPS/NOAAPORT satellite broadcast network (SBN)
 - 2. NWS FTP directory at:
ftp://tgftp.nws.noaa.gov/SL.us008001/DC.avspt/DS.cipgb/PT.grid_DF.gr1
 - 3. The family of services (FOS) high resolution data service and server access service

Web Interface

The CIP product images are also available for viewing on the public Internet (Figure 1) at the following URL:

<http://adds.aviationweather.gov/icing/>

The CIP is an automatically-generated product that supplements AIRMETs and SIGMETs by identifying areas of current icing potential, but it does NOT substitute for the intensity and forecast information contained in AIRMETs and SIGMETs. It is authorized for operational use by meteorologists and dispatchers.

Maximum Icing potential (FL010-FL300)

Analysis valid 1600 UTC Thu 09 Jun 2005

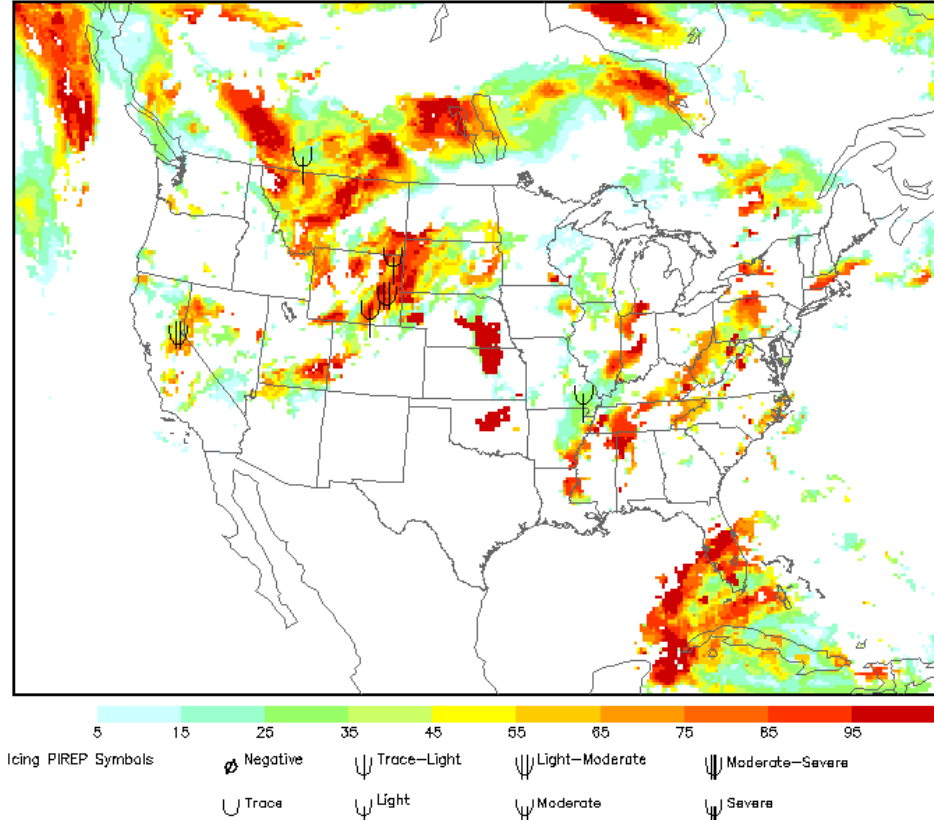


Figure 1: CIP 20 km Composite Image Valid 1600 UTC 9 June 2005

- e. **Feedback Method** - The Aviation Weather Center is always seeking to improve the representation of our products based on user feedback.

Comments regarding the CIP webpage should be sent to the feedback email address on the webpage containing the product.

Technical comments for the CIP product developer may be addressed to:

National Weather Service
Attn: Clinton Wallace, Chief, Aviation Support Branch
Aviation Weather Center
Phone: (816) 584-7248
Email: Clinton.Wallace@noaa.gov

Part II - Technical Description

- a. **Format and Science Basis** - The CIP algorithm calculates the TOTAL icing potential at a number of grid points vertically and horizontally. This is the reason that the colored plots of CIP appear to be blocky - the image is made up of a large number of color-filled grid boxes. The CIP also identifies regions of SLD, more likely to harbor drizzle-sized drops that can be more dangerous, especially for commuter planes and other propeller-driven aircraft lacking mechanisms that prevent or completely remove ice build-up. SLD is always included in the TOTAL icing. The SLD images include a gray background to indicate where the TOTAL icing exists.

The CIP determines TOTAL icing and SLD potentials in a stepwise fashion, and can be described in the following steps:

1. Place the datasets onto a common grid
2. Find the 3-D locations of clouds and precipitation using satellite, surface and radar observations
3. Apply fuzzy logic membership functions to icing-related fields to create interest maps
4. Determine the physical icing situation using a decision tree
5. Calculate the initial icing and SLD potentials by situationally combining interest maps from basic fields (e.g. T, RH)
6. Calculate the final icing potential by increasing or decreasing the initial icing potential using the vertical velocity, SLW and PIREP interest maps

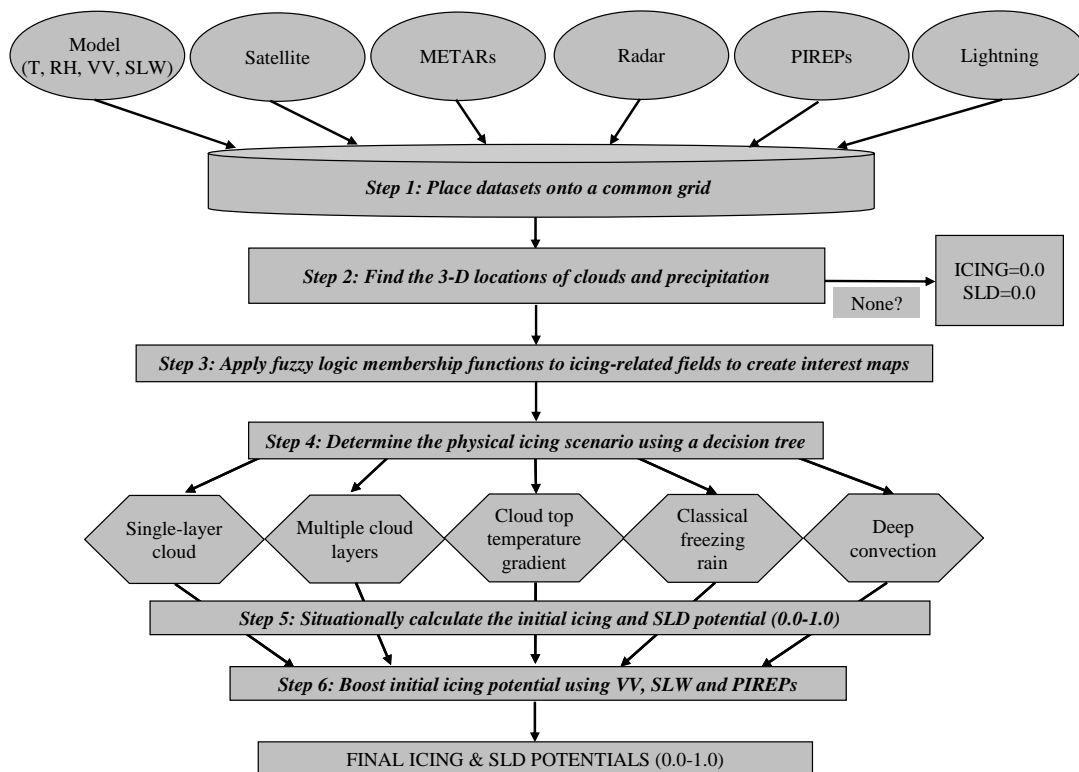


Figure 2: Flowchart of the CIP Process

Step 1: Place the datasets onto a common grid

The first step in the process is to map current satellite, surface, radar, lightning and PIREP observations as well as explicit model forecasts of supercooled liquid water content to the Rapid Update Cycle (RUC) model pressure grid. The RUC pressure grid supplies the temperature, relative humidity, vertical velocity and geopotential height fields with 25-mb vertical and 20-km horizontal grid spacing. Fields from the RUC 3-h forecast are typically used, but CIP could be run using other forecast lengths and even different models. The 0-h RUC diagnosis is not used because moisture parameters, including cloud microphysics typically need several hours to spin up.

Step 2: Find the 3-D locations of clouds and precipitation

Once the datasets have been mapped to the model grid, the matched data are examined to determine whether or not clouds are present in each model grid box. If adequate cloudiness is found, then cloud base and top heights, as well as the presence of precipitation and its type are assessed.

Step 3: Apply fuzzy logic membership functions to icing-related fields

An important element of the CIP technique is the use of fuzzy logic membership functions to develop interest maps for the temperature, relative humidity, cloud top temperature (CTT), vertical velocity, supercooled liquid water, and PIREP fields. Rather than applying thresholds, CIP attempts to handle uncertainties evident in the datasets it employs and to mimic the gradual transition from icing to non-icing environments associated with each field, based on cloud physics principles, experience gained from in-flight icing field programs and distributions of icing PIREPs relative to these parameters.

Steps 4 and 5: Determine the physical icing scenario and calculate the initial icing and SLD potentials

Icing and SLD conditions result from many processes, so the meteorological structure that is present must be identified, and the data and interest maps need to be applied in an appropriate manner. This situational approach is critical, since the meaning of an individual piece of data can be very different for different situations. CIP identifies five distinct icing situations: single-layer clouds, multiple-layer clouds, cloud top temperature gradients, classical freezing rain and deep convection.

Step 6: Calculate the final icing potential using boosting factors

In the final step, the situationally-derived initial icing potential (0.0-1.0 scale) is adjusted using recent pilot reports of icing and model forecasts of vertical velocity and supercooled liquid water. As described earlier, these fields are used in manual forecasting to increase or decrease confidence that icing will be present. Recent reports of icing and forecasts of upward motion and SLW can all increase the icing potential, while only a forecast of downward motion can decrease it. The maximum amount of increase is the difference between the initial icing potential and

unity (e.g. 0.6 for an initial icing potential of 0.4). SLW_{map} , $PIREP_{map}$ and VV_{map} can contribute boosts of as much as 40%, 35% and 25% of this value, respectively. When downward motion is forecast, the maximum decrease from VV_{map} is 25% of the difference between the initial icing potential and zero. These factors are not applied to the SLD potential field, since they have not been shown to be well correlated with the presence of SLD.

Overview of changes from previous Operational 40 km CIP

(1) New Data Set Inputs

a) RUC 20 km Hybrid B Grids

- i. The CIP uses the 20 km RUC pressure and hybrid-B grids, rather than the degraded 40-km resolution pressure grids.
- ii. Explicit cloud and rain water mixing ratio fields are now used to improve the icing field. Items i and ii bring the CIP in line with the Forecast Icing Potential (FIP), both in terms of resolution and model ingest fields.

b) National Lightning Network Data

- i. NLDN data is now used to identify areas deep convection, now included in the icing field.

(2) Physical Concept Upgrades

a) Addition of Deep Convection Scenario

- i. The previous operational CIP underestimated icing, including icing from SLD in areas of deep convection. When deep convection is active, icing is very likely, despite the presence of cold cloud tops. Strong upward motions generate copious amounts of liquid water and SLD, both at normal and well-below normal temperatures for icing. The new CIP deep convection scenario allows for both icing and SLD to occur at temperatures as cold as -30C, based on a special temperature map (T_{map}) for deep convection. Relative Humidity (RH) is not used because models have great difficulty forecasting moisture for these sub-grid scale features. Cloud top temperature (CTT) is also not used, because the cold cloud tops associated with deep convection are not associated with glaciation in the active stage of a thunderstorm's lifecycle, thanks to very strong updrafts and excessive supercooled liquid water (SLW) production. The deep convection scenario is turned on if lightning is observed within 25km of the center of a RUC-20 grid box. When this scenario is triggered, high icing and SLD potentials are indicated from just above the freezing level to about -20C, then taper off with decreasing temperature, reaching zero at -30C. Note that the addition of the deep convective scenario makes the algorithm more "correct", physically, but may actually hurt statistical results because a larger amount of high icing and SLD potential will be indicated. Pilot reports (PIREPs) in deep convection are expected to be rare, simply because aircraft avoid these areas.

b) Addition of Vertical Velocity Map and Supercooled Liquid Water Map

- i. A vertical velocity map (VV_{map}) and a supercooled liquid water map (SLW_{map}) are now included as "boosting factors". The previous operational CIP indicated low (<0.2) icing potential in deep, cold-topped

clouds, because partial or complete glaciation was expected as snow that forming in the upper portion of a cloud was expected to descend through the lower portion depleting the liquid water. However, experience has shown that where the RUC microphysics scheme explicitly predicts SLW, it's usually there. This boosts the confidence that icing is present, so this is used as a boosting factor in areas where CIP already shows an icing potential. Vertical velocity (VV) is also used as a booster. It is expected that more condensate is produced in upward-moving air, and experience confirms the numerical model is placing this in the correct locations. The approach and equations for both of these boosters are now with the operational FIP.

- b. **Product Availability and Transmission Schedule** - The CIP output will be available in two resolutions: 20 km and 40 km. Each resolution will be generated hourly in GRIB format with 20 km file sizes on the order of 2.5 MB and the 40 km file sizes on the order of 0.5 MB each.

CIP 20 km TOTAL ICE		CIP 20 km SLD ICE		CIP 20 km TOTAL ICE		CIP 20 km SLD ICE	
Level x 1000 ft	T+0	T+0	Level x 1000 ft	T+0	T+0	T+0	T+0
10	YIXA93 KKCI	YJXA93 KKCI	160	YIXA55 KKCI	YJXA55 KKCI		
20	YIXA95 KKCI	YJXA95 KKCI	170	YIXA53 KKCI	YJXA53 KKCI		
30	YIXA90 KKCI	YJXA90 KKCI	180	YIXA50 KKCI	YJXA50 KKCI		
40	YIXA84 KKCI	YJXA84 KKCI	190	YIXA48 KKCI	YJXA48 KKCI		
50	YIXA85 KKCI	YJXA85 KKCI	200	YIXA46 KKCI	YJXA46 KKCI		
60	YIXA81 KKCI	YJXA81 KKCI	210	YIXA45 KKCI	YJXA45 KKCI		
70	YIXA78 KKCI	YJXA78 KKCI	220	YIXA43 KKCI	YJXA43 KKCI		
80	YIXA75 KKCI	YJXA75 KKCI	230	YIXA41 KKCI	YJXA41 KKCI		
90	YIXA73 KKCI	YJXA73 KKCI	240	YIXA39 KKCI	YJXA39 KKCI		
100	YIXA70 KKCI	YJXA70 KKCI	250	YIXA38 KKCI	YJXA38 KKCI		
110	YIXA67 KKCI	YJXA67 KKCI	260	YIXA36 KKCI	YJXA36 KKCI		
120	YIXA65 KKCI	YJXA65 KKCI	270	YIXA34 KKCI	YJXA34 KKCI		
130	YIXA62 KKCI	YJXA62 KKCI	280	YIXA33 KKCI	YJXA33 KKCI		
140	YIXA60 KKCI	YJXA60 KKCI	290	YIXA32 KKCI	YJXA32 KKCI		
150	YIXA57 KKCI	YJXA57 KKCI	300	YIXA30 KKCI	YJXA30 KKCI		

The WMO Headers for the CIP 20 km

	CIP 40 km TOTAL ICE	CIP 40 km SLD ICE		CIP 40 km TOTAL ICE	CIP 40 km SLD ICE
Level x 1000 ft	T+0	T+0	Level x 1000 ft	T+0	T+0
10	YAWA93 KKCI	YAXA93 KKCI	160	YAWA55 KKCI	YAXA55 KKCI
20	YAWA95 KKCI	YAXA95 KKCI	170	YAWA53 KKCI	YAXA53 KKCI
30	YAWA90 KKCI	YAXA90 KKCI	180	YAWA50 KKCI	YAXA50 KKCI
40	YAWA84 KKCI	YAXA84 KKCI	190	YAWA48 KKCI	YAXA48 KKCI
50	YAWA85 KKCI	YAXA85 KKCI	200	YAWA46 KKCI	YAXA46 KKCI
60	YAWA81 KKCI	YAXA81 KKCI	210	YAWA45 KKCI	YAXA45 KKCI
70	YAWA78 KKCI	YAXA78 KKCI	220	YAWA43 KKCI	YAXA43 KKCI
80	YAWA75 KKCI	YAXA75 KKCI	230	YAWA41 KKCI	YAXA41 KKCI
90	YAWA73 KKCI	YAXA73 KKCI	240	YAWA39 KKCI	YAXA39 KKCI
100	YAWA70 KKCI	YAXA70 KKCI	250	YAWA38 KKCI	YAXA38 KKCI
110	YAWA67 KKCI	YAXA67 KKCI	260	YAWA36 KKCI	YAXA36 KKCI
120	YAWA65 KKCI	YAXA65 KKCI	270	YAWA34 KKCI	YAXA34 KKCI
130	YAWA62 KKCI	YAXA62 KKCI	280	YAWA33 KKCI	YAXA33 KKCI
140	YAWA60 KKCI	YAXA60 KKCI	290	YAWA32 KKCI	YAXA32 KKCI
150	YAWA57 KKCI	YAXA57 KKCI	300	YAWA30 KKCI	YAXA30 KKCI

The WMO Headers for the CIP 40 km